Space Weather Technical Forecast

Issued on Wednesday, 11 January 2023 at 01:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares likely. Chance of X-class flares (R3; Strong radio blackouts) throughout. A possible glancing blow from a CME on the 12th January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High over the past 24 hours, with an X1 flare observed at 10/2247 UTC, which originated from AR3186 near the northeast limb. Eight numbered sunspot regions cover the visible disc, with one un-numbered region. AR3182 in the southeast quadrant and AR3181 in the southwest remain the largest, most complex regions. AR3181 displays some leader spot emergence and continued growth. AR3182 has now lost the small delta spot in its trailer portion. AR3184 located in the far SE quadrant retains Gamma-Delta configuration. AR3186 in the far northeast has shown some trailing spot emergence. AR3180 and AR3183 appear little changed and relatively stable as they approach the west limb, as does the new unnumbered region. An M2 flare on 9th Jan from AR3181 in the southwest produced a CME which may give a glancing blow at Earth on day 2 (12th Jan), although this is a low probability. No other Earth-directed CMEs are in the forecast.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by DSCOVR at L1, started the period at slow-ambient levels but in recent hours have drifted above the slightly-elevated level. Density was average or below average. Total IMF, Bt, was predominantly weak, but with a slight upward drift, peak at 9 nT. The north-south component, Bz, showed a similar drift from often negative (southward) to positive (northward) but was weak, +8/-8 nT. Phi angle was generally negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 was at background levels, although with a small, short enhancement observed 24 hours ago at just after midnight UTC. High energy electron flux (greater than 2 MeV) has been at background to moderate levels, with a peak of 564 pfu observed at 10/1550 UTC. The 24-hour integrated electron fluence stayed well below the Active threshold, reaching 6.38e6 integrated pfu at 11/0001 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Moderate, with a continuing daily chance of X-class flares through the forecast period, these most likely from AR3182, AR3181, AR3184 or AR3186 which recently emerged across the limb.

Solar Wind / Geomagnetic Activity: The M2 flare on 9th Jan from AR3181 in the southwest generated a CME, which could give a glancing blow at Earth on day 2 (12th Jan), although this is a low probability. No other Earth-directed CMEs are in the forecast. Solar winds are now at slightly elevated levels, perhaps a result of CH62/-, with the rather muted HSS arrival. Geomagnetic activity is likely to be Quiet to Unsettled with a slight chance of Active or G1/Minor

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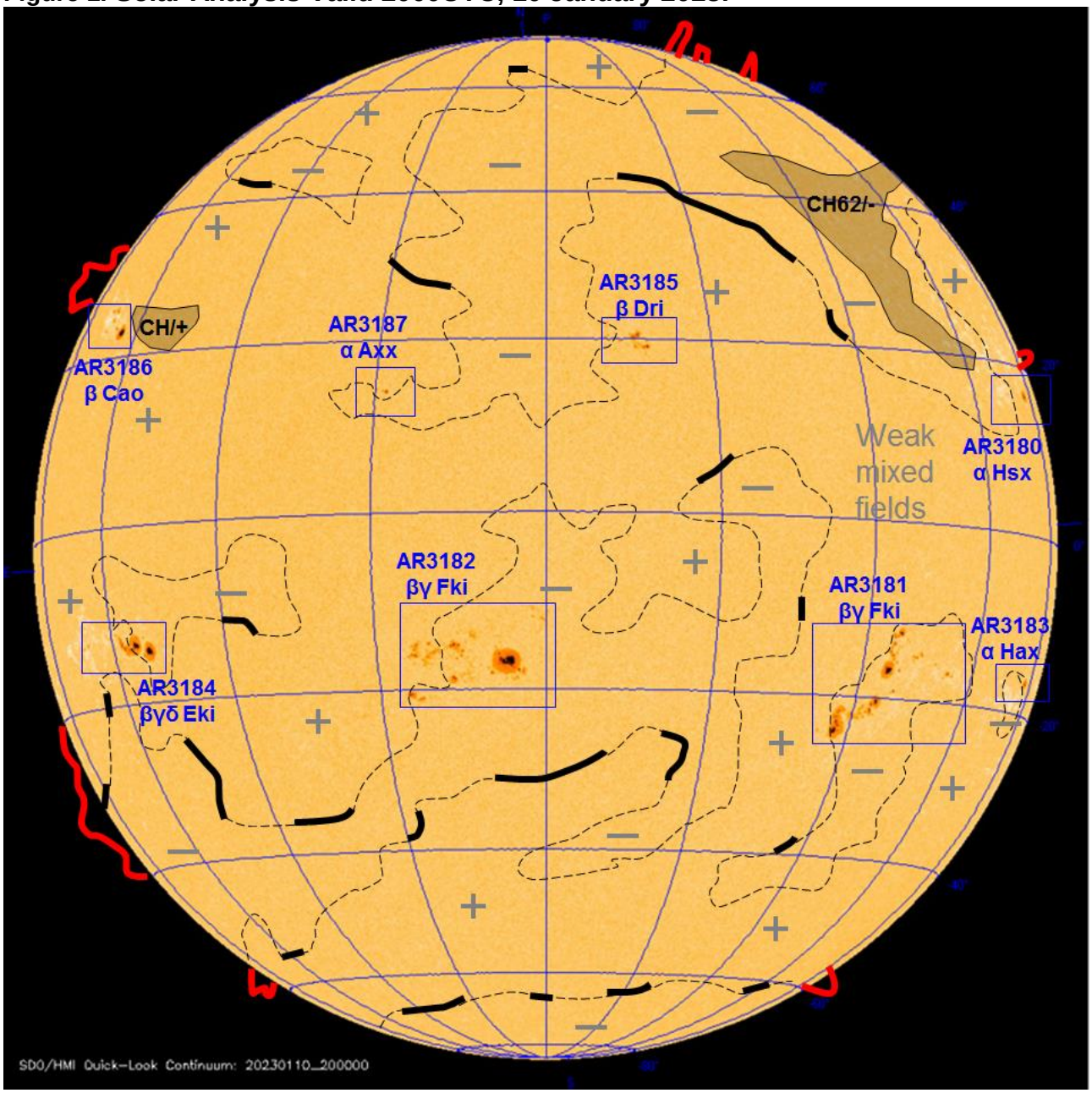
Storm Activity at first, and also again possibly during day 2 (12th Jan), from the glancing blow of the aforementioned CME, which may increase geomagnetic activity, potentially lasting into day 3 (13th Jan), before declining thereafter.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is likely to remain at background levels throughout. However, there is a risk of an increase should any significant flares occur, giving a slight chance of exceeding the S1/Minor Storm threshold. Electron fluence is likely to remain below the Active (1e8 integrated pfu) threshold, but a rise is possible towards the end of the period, depending on extent of coronal hole influence, and any glancing CME on day 2 (12th Jan).

Figure 1. Solar Analysis Valid 2000UTC, 10 January 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

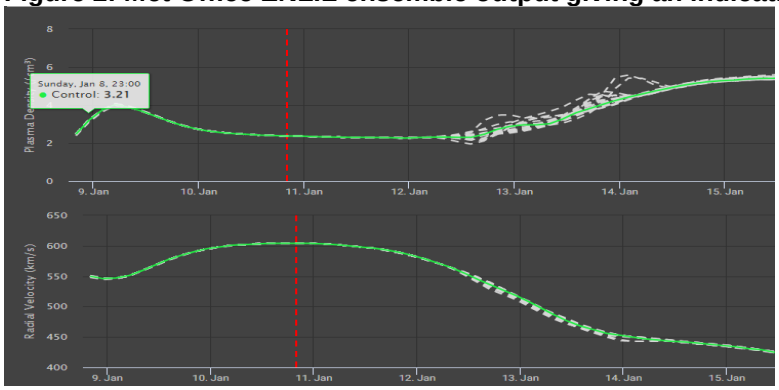
AR3181 in the southwest produced an M2 flare, observed at 09/0901 UTC, which produced a CME. This has been analysed and may give a glancing blow at Earth on Day 2 (12 Jan), although this is low confidence. No other Earth-directed CMEs are currently expected in the forecast. Solar wind speeds are at slightly-elevated levels, perhaps as a result of next feature of interest is CH62/-, with the rather muted HSS now connected to Earth. This feature was faintly visible on the previous rotation and didn't produce any significant HSS. It more clearly visible on this rotation suggesting a more significant response, however this is not supported by model output from the Met Office Solar Winds Prediction Model (SWPM), and a slow and erratic decline in solar winds levels over coming days is most likely to occur. Geomagnetic activity is expected to be Quiet to Unsettled with a slight chance of active or G1/Minor Storm Activity at first. A further enhancement may occur on Day 2 (12 Jan) due to a potential glancing blow from a CME - however this is low confidence, with solar activity mostly Quiet to Unsettled for days 3 and 4 (13th and 14th Jan).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
19/1908	Partial	AR3181	S30W31	445	12/2100	Low probability / low confidence of glancing blow

Figure 2: Met Office ENLIL ensemble output giving an indication of arrival times for the CME.



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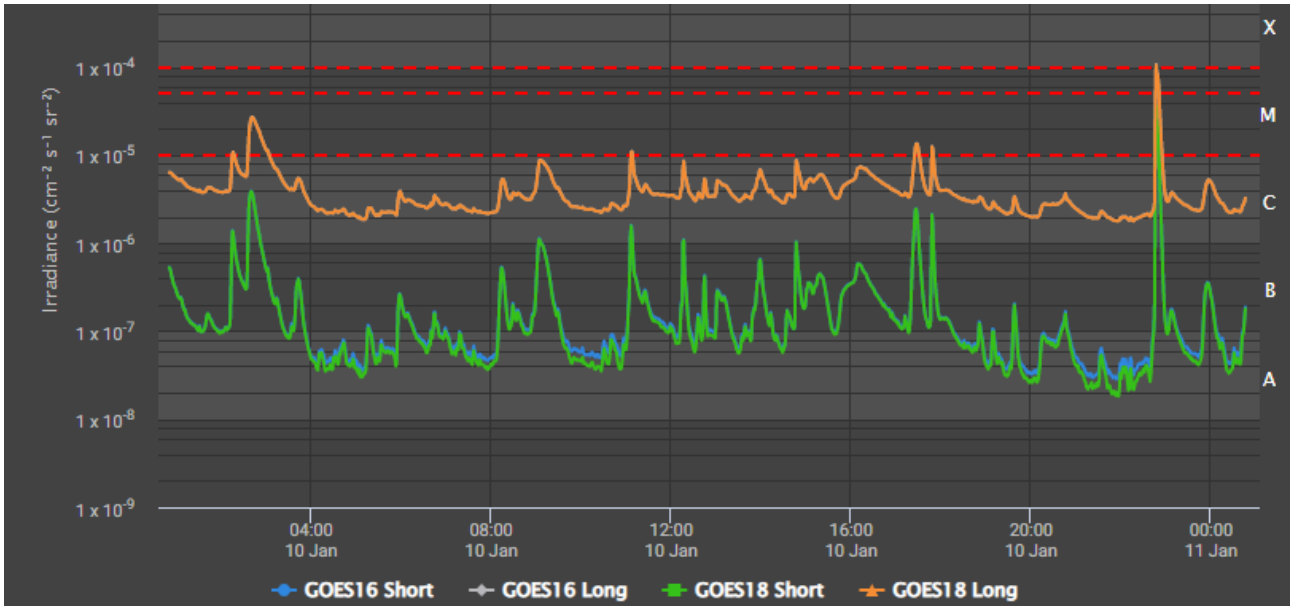
Radio Blackouts - X-Ray Flares:
Eight numbered sunspot regions cover the visible disc, with one un-numbered region. AR3182 in the southeast quadrant and AR3181 in the southwest remain the largest, most complex regions. AR3181 displays some leader spot emergence and continued growth. AR3182 has now lost the small delta spot in its trailer portion. AR3184 located in the far SE quadrant retains Gamma-Delta configuration. AR3186 in the far northeast has shown some trailing spot emergence. AR3180 and AR3183 appear little changed and relatively stable as they approach the west limb, as does the new unnumbered region.

Solar activity has been Moderate in the past 24 hours, Several M-flares were observed, the largest an M5 flare at 10/0016UTC from AR3186, at the northeast limb. Solar activity is likely to be Moderate with a chance of X-class flares. AR3182, AR3181, AR3184 or AR3186 are the most likely regions to produce further significant flares.

Far side seismographs are also indicating plenty of additional potential activity on the far side, and there are signs on SDO imagery of another large active region appearing on the southeast limb with flux looping evident and some magnetic structure on magnetogram products.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	90	90
Very Active	R3 to R5 X Class	Yes	25	25	25	25

Figure 3: X-ray flux plot showing the recent X-class flare from AR3186 in the northeast quadrant.



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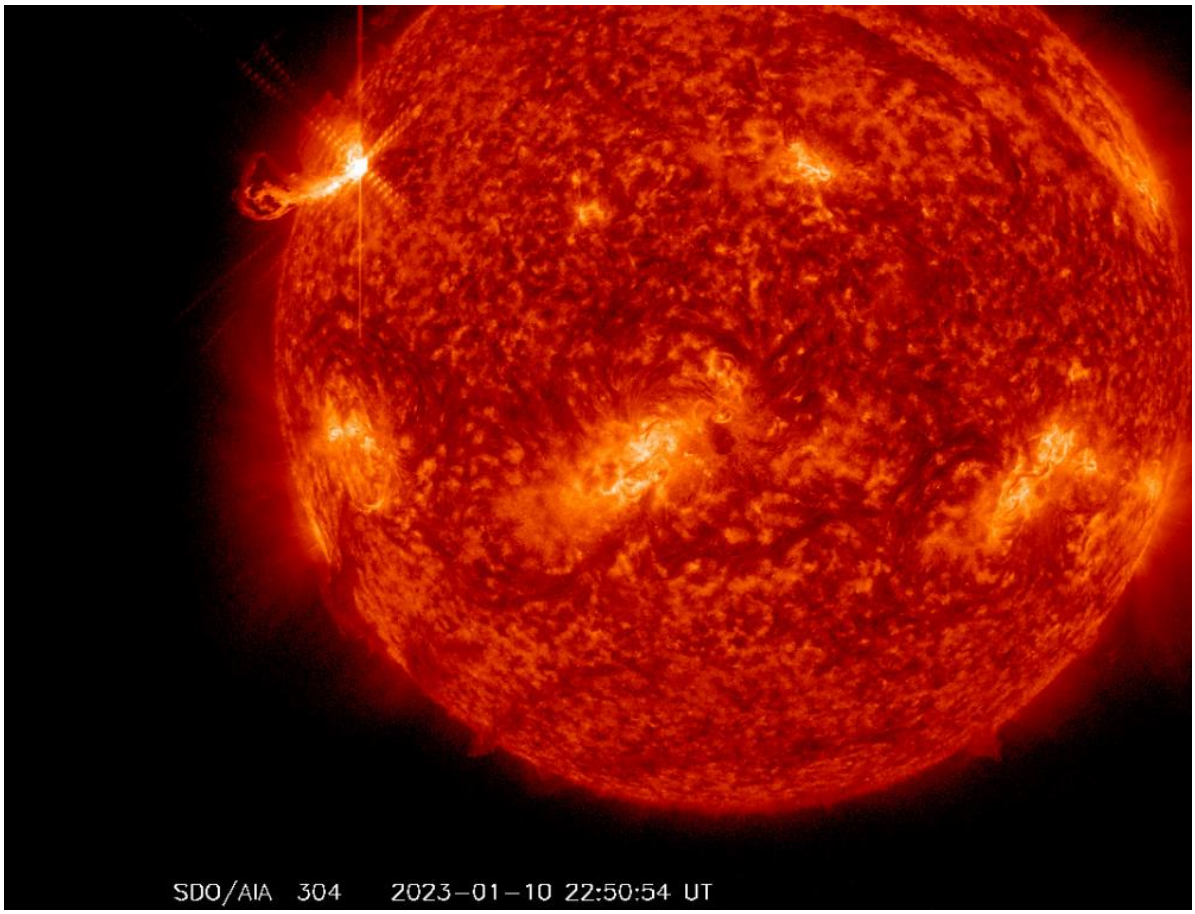
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 has been at background levels, although with a small, short enhancement observed 24 hours ago at just after midnight UTC. However, any significant flares will bring a risk of proton flux rising, with a slight chance of exceeding the S1/Minor Storm threshold. This is mainly due to the risk presented by both AR3182 and AR3181 as they are now rotating further westwards across the disc, towards a position where they are more likely to connect with Earth for proton storm events. AR3184 will also bear watching in the coming days, depending on how it appears and potentially develops as it rotates more fully across the visible solar disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	20	20	20	20
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO aia 304 satellite image showing the X-class flare from AR3186.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been at background to moderate levels. Any rise in activity is expected to be modest, perhaps reaching Moderate levels at the diurnal peaks. Any significant electron response is most likely to occur towards the end of this four day period - depending on any glancing blow from a CME on day 2 (12 Jan) which may keep electron flux levels suppressed.

Electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold through the period. Confidence in fluence remaining below Active through most of the period is reasonable, but lower for the likelihood and timing of any increase especially towards the end of the period, due to the extent of any coronal hole influence, and a possible glancing blow from the possible CME arrival during 12th Jan.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: High energy electron flux at GEO from GOES 16 and Met Office REFM output over past 3 days.

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